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Penetration of Anthropogenic ^{12}C, ^{13}C, and ^{14}C into the ocean: GCM simulations with implications for ocean uptake of bomb radiocarbon

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We have developed a carbon cycle model that computes distributions of total inorganic ^{12}C, ^{13}C and ^{14}C, phosphate, alkalinity, and dissolved organic matter in the world ocean. This model is based on the work of Maier-Reimer, Najjar, Archer, and others.This biogeochemical model is coupled to a version of the GFDL ocean general circulation model that incorporates (1) a dynamic sea-ice model and (2) the Gent-McWilliams parameterization for the impact of isopycnal eddies on advection and diffusion in the ocean.

We will present the result of three pre-industrial to present model runs with different surface carbon and carbon isotope boundary conditions: (1) with observed atmospheric forcing; (2) with observed forcing less the inferred atmospheric bomb radiocarbon; and (3) with the pre-industrial atmosphere plus the inferred bomb radiocarbon.

We have two major conclusions. First, forcing ocean models with observed atmospheric $\Delta^{14}C$ values introduces significant errors into estimates of ocean bomb-^{14}C uptake. Contrary to a common assumption, the number of atoms of bomb ^{14}C in the atmosphere is not directly proportional to atmospheric $\Delta^{14}C$, because of increasing concentrations of ^{12}C due to fossil fuel burning. Neglect of this fact results in underestimating the ocean bomb ^{14}C inventory after GEOSECS.

Second, neglect of increasing surface ocean ^{12}C concentrations has introduced a significant bias into the published estimates of ocean bomb ^{14}C concentrations based on the GEOSECS and other observations. These estimated bomb ^{14}C concentrations were made by subtracting $\Delta^{14}C$ values corresponding to estimated natural ^{14}C concentrations from observed $\Delta^{14}C$ values. Absent other anthropogenic influences (such as the Suess effect) on observed ocean $\Delta^{14}C$ values, this procedure would be correct. However, increasing ocean ^{12}C concentrations due to fossil fuel burning significantly affect observed ocean $\Delta^{14}C$ values. Neglect of this effect results in published inferred concentrations of ocean bomb 14C being significantly underestimated.

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